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C. Simmer

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C. Simmer

Universität Bonn
Auf dem Hügel 20, 53121 Bonn, Germany

Earth system modelling has always put highest demands on both memory and speed aspects of supercomputing. It can be forseen, that this will not change in the future due to at least four reasons:

1. Any subsystem we want to model, be it the atmosphere, the ocean or subsections of it, like boundary layers or limited areas, has quite strong interactions with many other subsystems. To take account of these interactions increasing the model area to include the interacting systems in one model is mostly inevitable. A good example are weather forecast models, which nowadays have to be global and soon have to include parts of the world oceans in order to further improve our ability to predict reliably e.g. the temperature in Jülich only several days ahead.

2. The interactions within Earth systems and at their boundaries cover always a very broad continuum of scales in both space and time. Any resolution cut-off demanded by restrictions in memory and computing speed must be payed for very dearly by the necessity to parameterize the cut-off processes as functions of the larger scales. It is obvious, that this will limit the quality of any simulation. Again weather forecast models may serve as an example: Their resolution has been constantly increasing from hundreds of kilometers in the beginning of numerical weather forcasting when the first electronic computers became available to now 7 km (e.g. the Lokalmodell (LM) of the German weather Servivce (DWD)). Still, the processes which affect our daily life most like clouds and precipitation, but also the air turbulence, are not yet modelled on the basis of first principles in the models but parameterized within the so-called physics-modules.

3. The complexity and number of indepent variables, which need to be taken into account in Earth system modelling, increases steadily and is virtually unlimited. Until recently, e.g. weather forcest model were based on the prediction of only five parameters (windspeed and horizontal direction, temperature, pressure and humidity) by solving simultaneously five interdependent partial differential equations in space and time at any point of the globe. Explicit treatment of the vertical velocity and cloud water have only recently entered the models. It can be foreseen, that first several condensate classes of hydrometeors (snow, hail, rain) will need be added, followed by subdividing these in several size classes, and followed by the addition of aerosol classes and trace gases (chemical weather).

4. Finally, by the extensions of the models as described above, both the amount of data to initialize the models, but even more the output produced during a simulation will multiply and has already achieved such a status, that output storage and output analysis has become a subject of major concern in Earth system modelling.

The three papers in this sections provide excellent examples especially for the first three topics described above. The papers are ordered according to scale beginning with mesoscale ocean modelling around 100 km resolution (Beismann and Redler), where sub-scale parametrizing of exchange processes is crucial. It follows mesoscale atmospheric chemistry modelling at a few kilometer resolution (Wolke et al.) where effort is put on intelligently organizing computer efficiency. The last contribution concernes large eddy simulation of the structure of the marine atmospheric boundary layer at 100 m resolution where both the inclusion of wet processes and a sufficiently large modelling area is stressed. (Raasch and Schröter).

The importance of sub-scale mixing processes for both the uptake and redistribution of tracers, and the formation and spreading of water masses in the world ocean is shown by Beismann and Redler. They use a medium resolution model (4/3 x 4/3 degrees) of the Atlantic Ocean basin to simulate the behaviour of the North Atlantic Deep Water (NADW) water, which is believed to be a highly influential water mass for decadal climate variations. They show, that the modelled behaviour of this water mass is strongly dependent on the mixing parametrisation applied. It becomes obvious, that small-scale phenomena like the filament-like Deep Western Boundary Current (DWDC), which cannot be adequately resolved by a model of this resolution, is a crucial component of the whole system. Higher resolution models are necessary to correctly account for its influence.

Wolke et al. adress in detail the problems encountered when coupling a weather forecast model (LM) with a chemistry transport model (MUSCAT). In the present version coupling is only one-way: The meteorological fields simulated by the LM are used for solving the equations of 73 species on the basis of 237 reactions. Both models are state-of-the-art models in their respective categories and extremely demanding concerning computer memory and speed. Multi-grid techniques are used to concentrate computing power in model areas, where highest resolution is necessary by dynamic allocation of processor loading. The coupling itself poses additional demands on efficiently organizing memory and data exchange. The authors can show, that especially the way MUSCAT is parallelized has achieved a very high efficiency. The expense of CPU power on coupling between the individual processors has been minimized.

Finally, Raasch and Schröter show a very successful application of massive by parallel computing for so-called Large Eddy Simulation (LES). LES extend atmospheric modelling from the scale applied for weather forecast models (usually around 10 km) down to below 100 m. A novel feature of this particular model is the inclusion of cloud physics. The authors were able to prove, probably for the first time, that the differences in aspect ratio (height to horizontal extend) between the classical dry Benard convection and the cellular convection in cold air outbreaks over warm ocean areas is caused by the moist processes. Liberation of latent heat during condensation of cloud water and its use-up during evaporation lead to much flatter observed aspect rations. An important prerequisite for the successful simulations was the possibility to largely increase the model area while keeping the high spatial resolution. It was necessary to model simultaneously many cells, which gives another hint, that this observed atmospheric process, most probably also many others, cannot be reproduced even in its basics by idealized settings which ignore both the effects of small scale processes and the large scale influences.